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Improving Housing Typology for Thermal Comfort in People's Housing Program: A case of Bharatpur

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Abstract

The People's Housing Program in Nepal, aimed at providing affordable housing solutions, faces significant challenges concerning thermal comfort. This study delves into these critical issues through comprehensive field measurements and survey analyses. Field measurements over a seven-day period revealed an enduring temperature difference of approximately 2 °C between indoor and outdoor environments, with indoor spaces consistently warmer. Survey data collected illuminated seasonal discomfort trends, with occupants experiencing a slightly cool sensation during winter and significant discomfort in the scorching summer months. The surveys further underscored widespread dissatisfaction with indoor thermal comfort and the existing building materials, particularly corrugated galvanized iron sheets. Despite these challenges, respondents expressed contentment with aspects such as building orientation, indoor air quality, relative humidity, natural lighting, and window dimensions. These findings not only highlight the urgent need for improving thermal comfort but also shed light on opportunities for leveraging occupant behavior. This study bridges the gap between research and practical application, advocating for alternative materials, construction techniques, and design strategies to achieve sustainable, cost-effective, and comfortable housing. Such efforts align with the overarching goals of inclusive and environmentally conscious development in Nepal.

Keywords

Thermal Comfort, People's Housing Program, Low-Cost Housing

1. Introduction

Established with the mission to provide affordable housing for marginalized communities in Nepal, the Janata Awas Karyakram stands as a beacon of hope for thousands of families grappling with inadequate shelter. This government-led initiative, often referred to as the People's Housing Program, addresses the pressing need for dignified living conditions among underserved populations, particularly those residing in rural and peri-urban areas. The Nepalese government engages with numerous stakeholders, including local authorities, non-governmental organizations, and community groups, to develop housing projects around the nation under the People's Housing Program [1]. The initiative focuses on building earthquake-resistant dwellings, particularly in seismically active locations, to improve community safety and resilience. Since its inception, the program has made significant strides in constructing basic housing units, aiming to uplift communities by providing them with a secure foundation from which they can build brighter futures.Started in 2009, it was first proposed for only three districts, namely; Siraha, Saptari and Kapilvastu, targeted for Dalit and poor Muslims. Later, it was expanded to 27 districts in 2016 and again to 72 districts in 2018 [2].

The initiative attempts to make housing more accessible to people and families with low financial means by emphasizing affordability. It combines cost-effective construction techniques and locally accessible materials to keep construction costs down while maintaining the quality and longevity of the dwellings. The People's Housing Program addresses not just the urgent need for housing, but also encourages long-term development and community empowerment. It emphasizes community engagement, local craftsmanship, and the use of new ways to increase energy efficiency and environmental sustainability in home designs. Overall, the People's Housing Program is critical in solving the housing difficulties faced by Nepal's marginalized people [1]. The initiative helps to improve living standards, reduce poverty, and build inclusive and sustainable communities by offering cheap and resilient housing alternatives.

Yet, amidst its laudable mission, the program encounters formidable hurdles in ensuring the holistic well-being of its beneficiaries. While providing shelter is undoubtedly crucial, the efficacy of any housing program must extend beyond mere bricks and mortar structures. It must encompass a broader vision that prioritizes energy efficiency, environmental sustainability, and thermal comfort. These pillars are not just lofty ideals but practical imperatives, essential for fostering healthy, resilient, and thriving communities. Thermal comfort is a fundamental aspect of housing design, influencing occupants' health, productivity, and overall quality of life. In regions like Nepal, characterized by diverse climatic conditions ranging from extreme cold in the mountains to oppressive heat in the Terai region, ensuring optimal indoor thermal conditions is essential for creating habitable and welcoming homes. Without adequate consideration for thermal comfort, residents may endure discomfort, health issues, and decreased satisfaction with their living spaces. Thermal comfort has long been associated with health and general well-being, but it also significantly enhances student productivity, concentration, and performance in educational facilities [3].

In light of these considerations, this study seeks to explore and address the challenges surrounding thermal comfort within the Janata Awas Karyakram. By examining current housing practices, identifying shortcomings, and proposing innovative solutions, the aim is to enhance the program's effectiveness and better meet the needs of its beneficiaries. Through a comprehensive approach that places thermal comfort at the forefront of housing design, this research endeavours to contribute to the creation of resilient, healthy, and livable communities across Nepal.

2. Research Objective

The research objectives include a thorough examination of the thermal performance and comfort features of the People's Housing Program and suggest more comfortable and sustainable housing solutions that are consistent with the larger aims of sustainable development and environmental stewardship. The specific objectives are:

- To evaluate the current thermal performance of People's Housing Program dwellings, identifying areas for enhancement.
- To propose novel design strategies to optimize thermal performance and enhance indoor comfort while considering cost-effectiveness.

3. Literature Review

Changing the building material for the envelope and roofing is one of the main ways to enhance energy efficiency, especially in low-cost houses, like the one we're talking about. A study has mentioned how the use of cost-effective construction practices like rat trap bond and filler slabs can reduce construction costs up to 26% if and when conducted properly [4]. Similarly, the use of earthen materials can not only drive down the cost but also result in better thermal performance. Research shows how implementing passive design strategies can enhance the thermal performance of a low-cost housing project [5]. Proper use of a bioclimatic chart and its analysis can help achieve great comfort at a low cost. A case study in thermal comfort presents improvement using light roof insulation, resulting in a 1.7°C improvement in the nighttime low and daytime high inside air temperature of a single room brick and tin roof home [6]. Also, a study shows how a low-cost building can also be thermally comfortable as well as seismically safe by implementing passive techniques and vernacular architectural practices [6]. The study of thermal comfort in a paper shows how difficult it can be to achieve thermal comfort in the Terai regions of Nepal [7]. In another study, the author presents how improving the envelope can enhance the thermal comfort of a cost-effective house [8]. The envelope is such an important factor in a building that, a poor envelope can reduce the livability of a building [9]. The use of bamboo instead of CGI sheets can help improve the building's thermal performance [9]. The questionnaire survey seems to be a great tool for surveying and studying people's experiences and habits [10]. Contemporary researchers [11], [12] typically initiate their studies by conducting field measurements, administering questionnaire surveys, and performing simulations to gauge people's perceptions of thermal comfort. Other papers [11] have also approached their study on the thermal comfort of a school building through simulations.

4. Methodology

The research methodology adopted in this study emphasizes a predominantly quantitative approach to comprehensively evaluate the thermal performance and occupants' comfort perception within Nepal's People's Housing Program. It integrates two primary data collection methods: field measurements and a structured questionnaire survey. Initially, an exhaustive review of pertinent literature, papers, and existing studies on energy-efficient housing practices, low-cost housing solutions, building materials, and innovative design techniques was conducted to establish a robust knowledge base. Subsequently, field measurements were meticulously executed to capture real-time environmental conditions, including temperature, humidity levels, and air quality, while a structured questionnaire survey was administered to residents to gather subjective perceptions and experiences related to thermal comfort and housing satisfaction. To evaluate the actual thermal conditions, temperature and relative humidity data were collected over seven days, both indoors and outdoors. Outdoor temperature readings were recorded every hour using data loggers equipped with solar radiation shields. This method provided

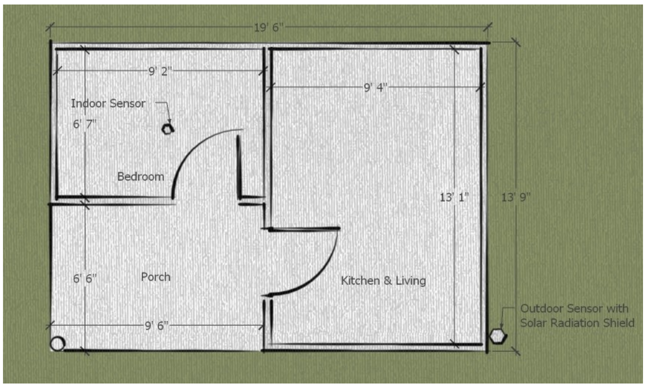

Figure 1: Layout of Building and Placement of Sensors

Figure 2: Outdoor Sensor with Solar Radiation Shield

Figure 3: Indoor Sensor

quantitative insights into the thermal conditions of the housing units throughout the day and night. The sensor for indoor reading was placed centrally in the bedroom and the one for outdoor reading was attached to the southeast wall. Both sensors were placed at a height of around 1.5 meters above ground. The placement of sensors can be more clearly observed in Figures 1, 2 and 3.

A structured survey was conducted among 32 beneficiaries of the People's Housing Program. The questionnaire collected demographic information, including gender, age, income, and literacy status. To gauge thermal comfort perceptions, occupants were asked about their experiences during both winter and summer seasons, assessing the impact on their daily activities and sleep patterns. Additionally, energy consumption patterns for cooking, water heating, and room heating and cooling were explored. The survey also inquired about signs of sick building syndrome and overall building satisfaction, covering aspects like orientation, thermal comfort, building materials, indoor air quality, relative humidity, lighting, and fenestration. Furthermore, respondents provided details on the current construction materials, including wall and roofing types and window characteristics.

The temperature and humidity data collected from the field measurements were analyzed for the relation between outdoor and indoor temperatures. This analysis provided insights into the thermal conditions within the housing units. Survey responses were analyzed using both quantitative and qualitative techniques. Quantitative data, including Likert-scale responses, were subjected to statistical analysis to identify trends and patterns in occupants' perceptions of thermal comfort and building satisfaction. Qualitative data from open-ended questions were thematically analyzed to gain deeper insights into occupants' experiences and preferences.

5. Study Area

The research area was chosen as Chitwan based on the fact that DUDBC had built over 1000 dwellings, with over 500 more completed after the project was handed over to the provincial government. Additionally, around 800 additional residences are scheduled to be developed under this scheme. With its findings, this research seeks to favourably affect future housing construction. Bharatpur Metropolitan City, Ward 29 was chosen from among the municipalities in the Chitwan district. Although the Bharatpur Metro is mostly developed, the outskirts, particularly the hilly sides populated by indigenous populations, are still underdeveloped. Furthermore, because we are researching thermal comfort, the climatic data from Bharatpur Airport accessible from DHM has the least variation when compared to any other regions in the district.

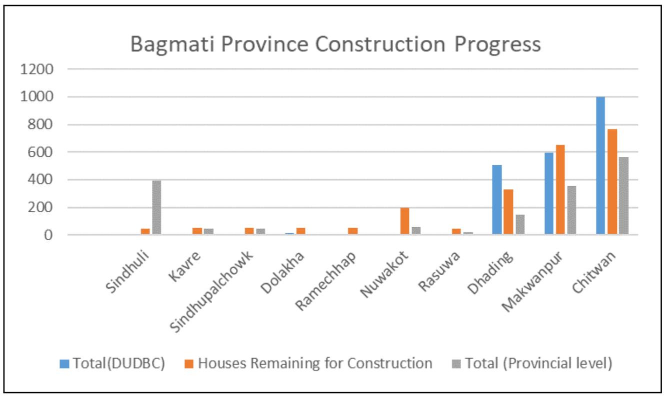

Figure 4: PHP Construction Progress in Bagmati Province

Within the Chitwan district, among various municipalities, Bharatpur Metropolitan City, Ward 29 was selected. Although Bharatpur Metro is majorly a developed area, the outskirt regions are still underdeveloped, especially the hilly sides inhabited by indigenous communities. Also, since we are studying for thermal comfort, the climate data of Bharatpur Airport available from DHM has the least discrepancy as compared to any other areas in the district.

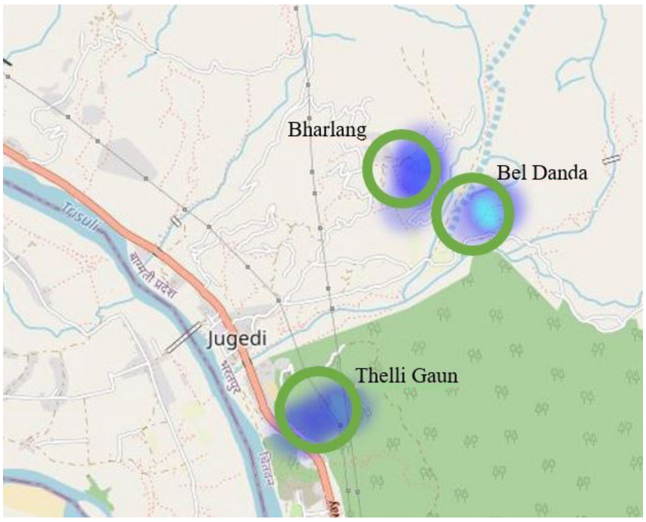

Figure 5: Map View of Surveyed Area

Three settlements were closely observed during the questionnaire survey, namely; Bel Danda, Bhargau and Thelli Gaun. All of these settlements had less than 10 houses. Further, the settlement was spread widely and towards the hilltops.

Figure 6: The Area Studied

The planned structure was typically a single level with two rooms and a porch. The bigger room was intended to be a living room and kitchen, while the smaller room was intended to be a bedroom. Figure 7 shows a typical floor plan of the buildings there.

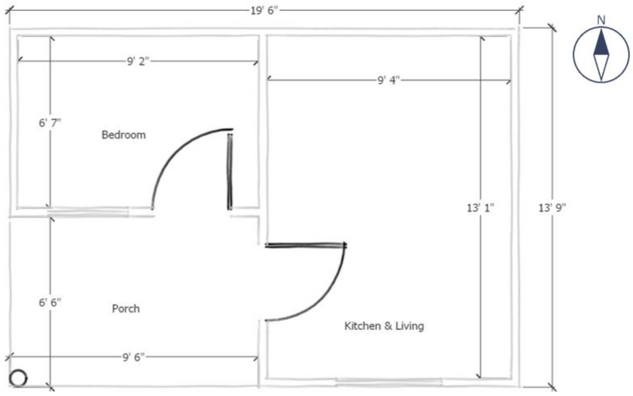

Figure 7: Typical Floor Plan

The majority of dwellings used concrete blocks to build their walls as can be seen in Figure 8, while stone walls covered with mud mortar were also seen in a few cases as seen in Figure 9.

Furthermore, all of the dwellings were distinguished by corrugated galvanized iron (CGI) sheet roofs. Notably, non-operable windows that stayed constantly open were a trait shared by virtually all of the residences.

Figure 8: Cement Blocks in Walls

Figure 9: Stone Walls with Mud Mortar

6. Results and Discussion

The temperature data recorded over 7 days show how the temperature peaks at around 2 p.m. and is lowest around 4 a.m.

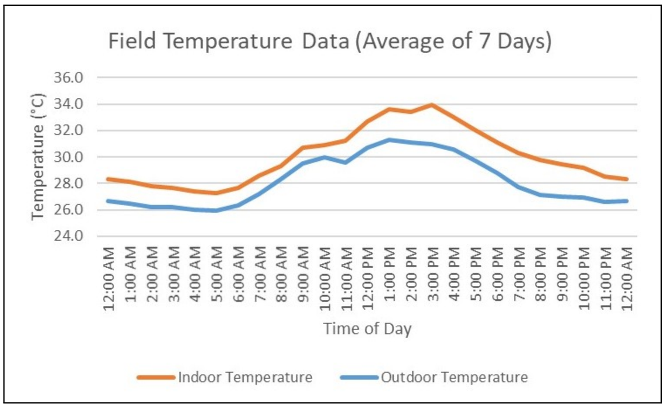

Figure 10: Field Temperature Data

It is to be duly noted that the indoor temperature is at all times higher than the outdoor temperature by around 2 degrees. The indoor temperature is desired to be less than that of outdoor. Here it is just the opposite and hence needs proper intervention for improvement.

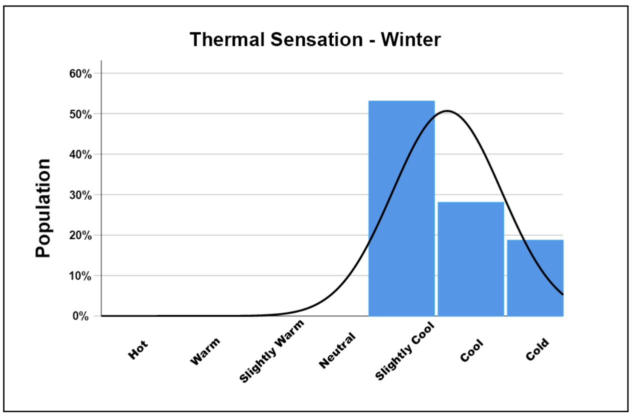

Figure 11: Thermal Sensation – Winter

From the questionnaire survey, the majority of the population experience a slightly cool sensation during winter. The above chart shows how the distribution is skewed towards colder sensations, however, it is bearable most of the time.

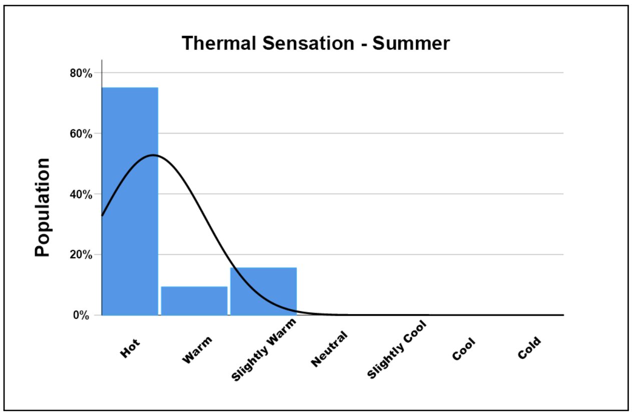

Figure 12: Thermal Sensation – Summer

On the contrary, summer seasons seem to present the residents with a harsh temperature. It is clear from the chart above that most of the population are unbearably uncomfortable due to high temperature during summer.

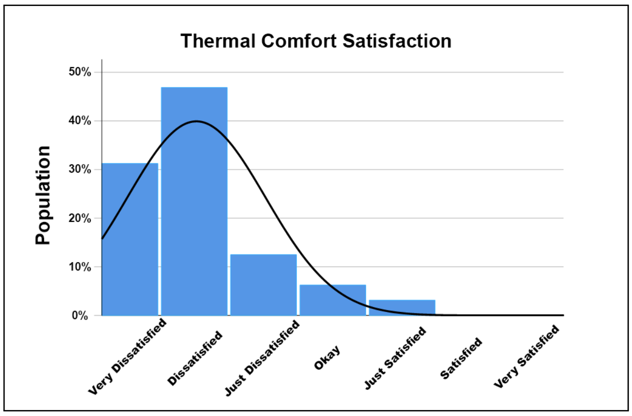

Figure 13: Thermal Comfort Satisfaction

Occupants are generally dissatisfied with the indoor thermal comfort in the houses. This can clearly be seen in the chart above. Majority of the population feel high discomfort indoors, especially during the summer season. They resort to resting outdoors, in the shed, or under large trees during summer days. The shade combined with a good amount of air flow in the open areas are supposed to make summer days a little more bearable. The indoors lack the required airflow and also take in more heat through the CGI sheet roofing.

The questionnaire survey results indicated substantial trends in inhabitants' experiences with temperature feelings. The bulk of the people reported feeling slightly chilled throughout the winter. The summer months, on the other hand, offered a different scene, with inhabitants experiencing severe and uncomfortably high temperatures. According to the survey, a sizable section of the population was unsatisfied with both interior thermal comfort and building material selection. Respondents, on the other hand, reported satisfaction with characteristics such as building orientation, interior air quality, and relative humidity. While over 80 percent of inhabitants voiced displeasure with interior thermal comfort, especially during the summer, many sought refuge outside, choosing shady locations or relaxing beneath giant trees to minimize the impacts of the high temperatures. Such shaded and well-ventilated spaces contributed to slightly improved comfort during the challenging summer days.

7. Conclusion and Recommendations

The study's findings underscore the pressing need to improve indoor thermal comfort within the People's Housing Program dwellings. It reveals widespread dissatisfaction among residents, primarily attributed to the subpar thermal performance of materials like CGI sheets. To address this, the research advocates for the adoption of alternative materials with superior thermal properties, such as clay tiles. Additionally, basic interventions like installing thin plywood ceilings emerge as cost-effective solutions to improve room temperatures, further supporting the research aim of considering cost-effectiveness in design strategies. Furthermore, advancements in wall materials, including stone walls and CSEB, offer promising avenues for enhancing thermal performance and indoor comfort, aligning with the objective of proposing novel design strategies. Ultimately, these efforts contribute to the broader goal of creating livable, affordable, and eco-friendly communities in Nepal's People's Housing Program.

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